IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Patent Application of

LI et al

Serial No. 09/493,258

Filed: 28 January 2000

For: INCREMENTAL INTERLACE INTERPOLATION FOR TEXTURE MORPHING

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Examiner: Good-Johnson

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APPEAL BRIEF

Sir:

Applicant hereby **appeals** to the Board of Patent Appeals and Interferences from the last decision of the Examiner.

REAL PARTY IN INTEREST

The real party in interest is Nintendo Co., Ltd., a corporation of the country of Japan.

RELATED APPEALS AND INTERFERENCES

The appellant, the undersigned, and the assignee are not aware of any prior or pending appeals, interferences or judicial proceedings which may be related to, directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

STATUS OF CLAIMS

The following is the status of the claims in this proceeding:

- Claims 1, 3-14 and 16-34 are pending;
- Claims 1, 3-8, 11-14, 16-21, 24-27 and 34 are rejected and therefore are the subject of this appeal;
- Claims 9, 10, 22, 23 and 28-31 are allowed[1];
- Claims 2 and 15 were canceled without prejudice or disclaimer.

STATUS OF AMENDMENTS

No amendments have been filed since the Final Rejection.

SUMMARY OF CLAIMED SUBJECT MATTER

Applicants' rejected independent claims are numbered 1, 14, 27, 32, 33 and 34.

Applicants' independent claim 1 is directed, "in a real time interactive graphics system" (see e.g., Figure 1 and specification page 5, line 19 and following), to "a method for morphing and displaying a texture-mapped object." (See e.g., Figure 2). Applicants' method of claim 1 requires:

[1] The Examiner indicates on page 7 of the Office Action that "Claims 9, 10, 22, 23 and 28-31 are allowed." Therefore, applicants assume that the Examiner's indication on the front page of the Office Action states that "Claim(s) 9, 10, 21, 22, 28-31 is/are allowed" includes a typographical error, i.e., "21, 22" should read "22, 23".

- "pre-decomposing at least some texels of a texture map representing a 2D image into respective texel color components" (for exemplary support, see e.g., Figure 2 step 106 and specification page 8, lines 21 and following);
- "predetermining, based on said decomposed texture map and target texel color component states defined by a target texture map defining a target morph texture map providing a target 2D image, at least one incremental morph parameter corresponding to said respective texel color components" (for exemplary support, see e.g., Figure 3 block 108 and specification page 9, lines 1 and following);
- "using said incremental morph parameter during real-time imaging to incrementally interpolate said texel color components toward target texel color component states through at least one intermediate morph texel color component state to provide a morphed texture map representing a morphed 2D image;" (for exemplary support, see Figure 3 block 110 and specification page 9, lines 6 and following); and
- "displaying an image based at least in part on said intermediate morph texel color state by texture mapping said morphed texture map to apply said morphed 2D image onto a surface of said object" (for exemplary support, see e.g., Figure 1 and specification page 6, lines 5 and following)

Independent claim 1 further requires "wherein said incrementally interpolating comprises repetitively adding said predetermined incremental morph parameter to said predetermined texel components to produce a corresponding sequence of intermediate

morph texel component states defining morphed texture maps representing 2D images." (for exemplary support, see Figure 5 and specification page 11, lines 20 and following).

Rejected independent claim 14 requires a "real time interactive graphics system for morphing and displaying a texture-mapped object" comprising:

- "a color decomposer that pre-decomposes at least some texels of a texture map representing a 2D image into respective texel color components (for exemplary support, see e.g., Figure 2 step 106 and specification page 8, lines 21 and following);
- "a predeterminer that predetermines incremental texture component morph parameters based on said decomposed texels and target morph texture texel color component states defined by a target texture map representing a target 2D image," (for exemplary support, see e.g., Figure 3 block 108 and specification page 9, lines 1 and following)
- "an incremental interpolator that incrementally interpolates, in response to said predetermined incremental morph parameters, said texel components toward said target texel color component states through at least one intermediate morph texel component state to provide a morphed texture map representing a morphed 2D image;" (for exemplary support, see Figure 3 block 110 and specification page 9, lines 6 and following)
- "a real-time image generator that generates a display based at least in part on said intermediate morph texel component state by texture mapping said morphed texture map to apply said morphed 2D image onto a surface of an

object in real time response to user inputs," (for exemplary support, see e.g., Figure 1 and specification page 6, lines 5 and following).

Independent claim 14 further requires "wherein said incremental interpolator repetitively adds said incremental morph parameters to the texel components to produce a corresponding sequence of intermediate morph texel component states defining morphed texture maps representing 2D images." (for exemplary support, see Figure 5 and specification page 11, lines 20 and following).

Rejected independent claim 27 is directed to an "efficient method for morphing and displaying texture-mapped objects using a real-time interactive 3D graphics system including user-manipulable controls, said system displaying at least one 3D texture-mapped object based at least in part on a morphed texture map comprising plural texels defining a texture image." (see e.g., Figure 1 and specification page 5, line 19 and following). The claimed method includes the following steps:

- "before real time imaging, pre-decomposing said texture map representing said 2D image into plural texel components and precalculating incremental morph parameter values for the texel components;" (for exemplary support, see e.g., Figure 2 step 106 and specification page 8, lines 21 and following)
- "during real-time imaging, incrementally changing the values of said plural texel components over time based on said calculated incremental morph parameter values to provide morphed texture maps representing morphed 2D images;" (for exemplary support, see Figure 3 block 110 and specification page 9, lines 6 and following)

- "during real-time imaging, generating images in real time based at least in part on said incrementally-changing texel component values by texture mapping said morphed texture maps to apply said morphed 2D images onto at least one 3D object surface in real time response to user operation of said controls," (for exemplary support, see e.g., Figure 1 and specification page 6, lines 5 and following).

Claim 27 further requires "wherein said incrementally changing step repetitively adds said calculated incremental morph parameter values to the texel components to produce a corresponding sequence of intermediate morph texel component states defining morphed texture maps representing 2D images." (for exemplary support see e.g., Figure 7 block 318 and specification page 18, lines 3 and following).

Rejected independent claim 32 is directed to "an efficient texture morphing method for morphing and displaying texture-mapped objects using a real time interactive 3D graphics system including user-manipulable controls, said system displaying at least one 3D object based at least in part on a morphed texture map comprising plural texels representing a 2D image, each texel comprising plural texel components." See Figure 1 and page 5, line 18 and following. The recited "texture morphing and display method" includes:

- "before real-time imaging, pre-decomposing said texels of said texture map representing a 2D image into plural texel components and precalculating incremental morph parameter values for said texel components, including

rounding down calculated incremental interpolation values to the closest integer values to provide integer results and calculating period counter values based on non-integer remainders of said calculated incremental interpolation values;" (for exemplary support, see e.g., Figure 2 step 106 and specification page 8, lines 21 and following, and specification page 15, lines 8 and following)

- "at least in partial response to user interaction with said controls, changing texel component values at a first periodic frequency based on said integer results;" (for exemplary support, see Figure 7 and specification at page 15, last line and following)
- "at least in partial response to said period counter, further changing said texel component values at a second periodic frequency less than said first periodic frequency to compensate for approximation errors introduced by step (b);" (for exemplary support, see specification at page 18, line 4 and following).
- "generating an image display based at least in part on said changed and further changed texel component values by texture mapping said morphed texture maps to apply corresponding 2D images onto at least one object surface." (for exemplary support, see e.g., Figure 1 and specification page 6, lines 5 and following)

Rejected independent claim 33 is directed to a method "In a real-time interactive graphics system including at least one user-manipulable control, a method for generating

animation objects in real time by morphing a source texture map representing a 2D source image including plural texels each having plural components, into a target texture map representing a 2D target image including plural texels each having plural components". See Figure 1 and page 5, line 18 and following. The recited method comprises:

- "calculating incremental morph parameter values for texels of said first texture map, and incrementally interpolating the value of said plural texel components of said first texture map over time based on said calculated uniform incremental morph parameter values so as to morph said first texture map toward said second texture map including repetitively adding said incremental morph parameters to the texel components to produce a corresponding sequence of intermediate morphed texel component states;" (for exemplary support, see Figure 3 block 110 and specification page 9, lines 6 and following)

- "using an intermediate texture map generated by step (a) to texture map said intermediate morphed texel component states onto a surface of at least one animation object to thereby apply a morphed 2D image onto said surface;" (for exemplary support, see Figure 3 block 110 and specification page 9, lines 6 and following)
- "controlling at least one of the displayed orientation and position of said texture-mapped animation object at least in part in response to user

manipulation of said control;" (for exemplary support, see Figure 2 and page 6, line 2 and following)

- "generating an image based at least in part on said controlled texture-mapped animation object." (for exemplary support, see e.g., Figure 1 and specification page 6, lines 5 and following)

Rejected independent claim 34 is directed to a "storage device for use with a real-time interactive graphics system including at least one user-manipulable control, said storage device storing information used by said system for generating animation objects in real time by morphing a source texture map representing a 2D source image including plural texels each having plural components, into a target texture map representing a 2D target image including plural texels each having plural components." See Figure 3A item 56 and page 6, lines 2 and following. The recited storage device comprises:

- "a first storage portion that stores information controlling said system to calculate incremental morph parameter values for texels of said source texture map, and to incrementally interpolate the values of said plural texel components of said first texture map over time into values of plural texel components of said target texture map by uniform integer amounts based on said calculated incremental morph parameter values so as to morph said source texture map through at least one intermediate texture map toward said target texture map;" (for exemplary support, see Figure 3A item 56-3, Figure 3 block 110 and specification page 9, lines 6 and following)

- "a second storage portion that stores information controlling said system to texture-map said intermediate texture map onto at least one surface of an animation object to thereby apply a morphed 2D image onto said surface" (for exemplary support see Figure 3A item 56-1).
- "a third storage portion that stores information controlling at least one of the displayed orientation and position for display of said texture-mapped animation object at least in part in response to user manipulation of said control." (for exemplary support see Figure 3A item 56-5 and page 6, lines 3 and following).

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The only issue in this case is whether claims 1, 3-8, 11-14, 16-21, 24-27 and 32-34 are "anticipated" under 35 USC 102(a) by Blanz et al., *A Morphable Model for the Synthesis of 3D Faces*, ACM SIGGRAPH 1999, pages 187-194.

ARGUMENT

In computer graphics, metamorphosis, or "morphing", is the process of gradually changing a source object through intermediate objects into a target object. For example, a person's face can be morphed into another person's face, an animal can be morphed into a human, etc. See Figure 2 for example.

Past advancements in 3D morphing have tended to concentrate on developing algorithms for morphing geometry between source and target objects. However, modern 3D graphics commonly uses texture mapping to make 3D objects more interesting and apparently more complex. Generally, texture mapping involves taking a 2D image (e.g.,

a photographic or other digitized picture) and placing it onto a 3D surface. As one example, a brick wall can be imaged by mapping a brick-and-mortar texture onto a simple rectangular surface of a 3D "wall" object. Images of foliage, clouds, and a variety of other complex images can all be created using such texture mapping techniques.

When attempting to morph a textured 3D image, one must morph the texture as well as the geometry. Texture maps can be large, and each texel in the map should be morphed to provide a range of interpolated texture values between source and target textures. Such texture morphing therefore tends to be computationally expensive -- effectively preventing resource-constrained real-time graphics systems such as home video game systems and personal computer graphics cards from providing real-time texture morphing functionality.

Applicants have invented a new texture morphing procedure that is fast and efficient enough to be performed in real-time within limited resource environments (e.g., video game platforms) so that texture morphing can be performed "on the fly" in a limited resource graphics system.

The applied Blanz reference teaches the geometric morphing of a 3D object (human face) via linear combination. Blanz's algorithm modifies and maps a <u>single</u> original texture onto the 3D shape. Blanz significantly differs from applicants' subject matter claimed in at least claims 1, 14, 23 and 34 -- which provides a smooth transformation between <u>two textures</u> (source <u>and target</u> textures).

The Examiner appears to contend that applicants' claimed "target texture map" corresponds to Blanz's "morphable model" disclosed at page 189, section 3. However, it

appears that what Blanz is actually doing is applying his single original texture to the geometry of his "morphable model." Blanz's approach is therefore fundamentally different from the type of "texture morphing" (i.e., morphing between an initial texture map and a target texture map) that applicants describe and claim in rejected independent claims 1 ("target morph texture map"), 14 ("target texture map"), 23 ("target morph texture texel color component states"), 33 ("toward said second texture map") and 34 ("target texture map").

Furthermore, the incremental interpolation applicants describe provide sequential (e.g., small) steps along a progressive procedure. Blanz does not teach or suggest this approach. Blanz algorithm's uses "incremental" to refer to a single subtle change from the original data – not a repetitive incrementing process as applicants claim. To the extent Blanz's "ΔT" value can be characterized as a "predetermined incremental morph parameter", it is added or subtracted to provide a single final image – not a sequence of intermediate images. In contrast, applicant's disclosed subject matter provides and displays intermediate results of steps along the texture morphing procedure. This feature is recited in each of rejected independent claims 1 ("repetitively adding ...", 14 ("repetitively adds ..."), 27 ("repetitively adds ..."), 32 ("changing texel component values at a first periodic frequency ...."), and 33 ("repetitively adding ...").. See also applicants' various claim limitations requiring display of intermediate results (e.g., recitation in claims 1 and 14 of "corresponding sequence of intermediate morph texel component states ...", claim 27's recitation of "corresponding sequence of intermediate morph texel components to produce a corresponding sequence of intermediate morph

texel component states defining morphed texture maps representing 2D images"), and recitation in claim 33 and 34 of "intermediate texture map". These further distinguish over Blanz.

In addition, the recitation in claim 32 of "changing texel component values at a first periodic frequency ... further changing said texel component values at a second periodic frequency less than said first periodic frequency to compensate for approximation errors ..." is nowhere taught or suggested by Blanz. The Examiner is relying on Blanz's disclosure of "computations of derivatives" in each "iteration step" at page 193 section 7, but the "iteration step" Blanz refers to appears to be his recursion to match a morphable model into a single image as shown in Figure 6 and described on page 192. Applicants do not understand how the Examiner obtains from this Blanz disclosure any suggestion to change texel component values at different periodic frequencies to compensate for approximation errors. There is simply no basis for the Examiner to equate Blanz's optic flow algorithm for different resolution levels with applicants' rounding technique for avoiding approximation errors.

Furthermore, Blanz algorithm is a non-real time procedure. In contrast, the applicants disclose a <u>real time</u> imaging procedure that can produce the images "on-the-fly" at runtime. Blanz provides a very sophisticated approach transforming the geometry (shape) and applying corresponding geometry-defining vertex colors. It seems unlikely that such a sophisticated process could be performed in real time on a limited capability computing platform such as a home video game system. To the extent that certain of applicants' claims explicitly require "real time", this is yet another distinction over Blanz.

The Examiner did not attempt to reject applicants' claims under 35 USC 103. However, for the same reasons set forth above, applicants believe their claimed subject matter is not suggested by (and therefore not "obvious" in view of) Blanz.

CONCLUSION

The Examiner has failed to meet the burden of demonstrating unpatentability of applicant's claims over Blanz.

In conclusion it is believed that the application is in clear condition for allowance; therefore, early reversal of the Final Rejection and passage of the subject application to issue are earnestly solicited.

Respectfully submitted,

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APPENDIX

CLAIMS ON APPEAL

1. (Rejected) In a real time interactive graphics system, a method for morphing and displaying a texture-mapped object comprising:

pre-decomposing at least some texels of a texture map representing a 2D image into respective texel color components;

predetermining, based on said decomposed texture map and target texel color component states defined by a target texture map defining a target morph texture map providing a target 2D image, at least one incremental morph parameter corresponding to said respective texel color components,

using said incremental morph parameter during real-time imaging to incrementally interpolate said texel color components toward target texel color component states through at least one intermediate morph texel color component state to provide a morphed texture map representing a morphed 2D image; and

displaying an image based at least in part on said intermediate morph texel color state by texture mapping said morphed texture map to apply said morphed 2D image onto a surface of said object,

wherein said incrementally interpolating comprises repetitively adding said predetermined incremental morph parameter to said predetermined texel components to produce a corresponding sequence of intermediate morph texel component states defining morphed texture maps representing 2D images.

Claim 2 previously canceled without prejudice or disclaimer.

3. (Rejected) A method as in claim 1 wherein said incrementally interpolating comprises using an integer arithmetic calculation to repetitively increment or decrement said plural texel components based on said predetermined incremental morph parameter.

4. (Rejected) A method as in claim 1 wherein said predetermining calculates said incremental morph parameter as the amount of change in said texel components for each successive time period within a morphing procedure, and said incrementally interpolating changes said texel components in response to the integer portions of said incremental morph parameters.

5. (Rejected) A method as in claim 4 wherein said successive time periods comprise image frame times.

6. (Rejected) A method as in claim 4 wherein said incrementally interpolating conditions said change in said texel components based on which of said successive time periods has occurred within said morphing procedure to minimize the number of calculations required to morph said texture.

7. (Rejected) A method as in claim 4 further including selectively adding integers to or subtracting integers from said integer portions to reduce approximation errors in the context of integer arithmetic operations.

8. (Rejected) A method as in claim 1 wherein said incremental interpolation comprises incrementing or decrementing said texel components by integer

approximations of said determined morph parameters, and compensating for approximation errors by performing at least one floating point operation to set said texel components to target texel component values.

9. (Allowed) A method for morphing and displaying a texture comprising:

pre-decomposing at least some texels of a texture map into respective texel color components;

predetermining, based on said decomposed texture map and target texel color component states defined by a target morph texture map defining a target morph texture, at least one incremental morph parameter corresponding to said respective texel color components,

using said incremental morph parameter during real-time imaging to incrementally interpolate said texel color components toward target texel color component states through at least one intermediate morph texel color component state; and

displaying an image based at least in part on said intermediate morph texel color state,

wherein said incrementally interpolating comprises repetitively adding said predetermined incremental morph parameter to said predetermined texel components to produce a corresponding sequence of intermediate morph texel component states;

wherein said incremental interpolation selectively interpolates said texel components based on an interlace factor.

10. (Allowed) A method for morphing and displaying a texture comprising:

pre-decomposing at least some texels of a texture map into respective texel color components;

predetermining, based on said decomposed texture map and target texel color component states defined by a target morph texture map defining a target morph texture, at least one incremental morph parameter corresponding to said respective texel color components,

using said incremental morph parameter during real-time imaging to incrementally interpolate said texel color components toward target texel color component states through at least one intermediate morph texel color component state; and

displaying an image based at least in part on said intermediate morph texel color state,

wherein said incrementally interpolating comprises repetitively adding said predetermined incremental morph parameter to said predetermined texel components to produce a corresponding sequence of intermediate morph texel component states;

further including conditioning said incremental interpolation step based on an interlace factor.

11. (Rejected) A method as in claim 1 further including calculating a frame counter corresponding to said texel components, and selectively incrementing or decrementing said texel components in response to said frame counter.

12. (Rejected) A method as in claim 1 further including the preliminary step of storing said decomposed texel components in separate texel component arrays.

13. (Rejected) A method as in claim 12 wherein said texel components comprise red, green and blue color values and an alpha value.

14. (Rejected) A real time interactive graphics system for morphing and displaying a texture-mapped object comprising:

a color decomposer that pre-decomposes at least some texels of a texture map representing a 2D image into respective texel color components;

a predeterminer that predetermines incremental texture component morph parameters based on said decomposed texels and target morph texture texel color component states defined by a target texture map representing a target 2D image,

an incremental interpolator that incrementally interpolates, in response to said predetermined incremental morph parameters, said texel components toward said target texel color component states through at least one intermediate morph texel component state to provide a morphed texture map representing a morphed 2D image; and

a real-time image generator that generates a display based at least in part on said intermediate morph texel component state by texture mapping said morphed texture map to apply said morphed 2D image onto a surface of an object in real time response to user inputs,

wherein said incremental interpolator repetitively adds said incremental morph parameters to the texel components to produce a corresponding sequence of intermediate morph texel component states defining morphed texture maps representing 2D images.

Claim 15 previously canceled without prejudice or disclaimer.

16. (Rejected) A system as in claim 14 wherein said incremental interpolator comprises an arithmetic calculator that performs a repetitive integer arithmetic calculation to repetitively increment or decrement said plural texel components based on said determined incremental morph parameters.

17. (Rejected) A system as in claim 14 wherein said incremental interpolator calculates said incremental morph parameter as the amount of change in said texel components for each successive time period within a morphing procedure, and changes said texel components in response to the integer portion of said incremental morph parameters.

18. (Rejected) A system as in claim 17 wherein said successive time periods comprise image frame times.

19. (Rejected) A system as in claim 17 wherein said incremental interpolator conditions said change in said texel components based on which of said successive time periods has occurred within said morphing procedure to as to reduce the number of calculations required to morph said texture.

20. (Rejected) A system as in claim 17 further including an adder that selectively adds or subtracts 1 relative to said integer portion to minimize approximation errors in the context of integer arithmetic operations.

21. (Rejected) A system as in claim 14 wherein said incremental interpolator increments or decrements said texel components by integer approximations of said determined morph parameters, and compensates for approximation errors by performing at least one floating point operation to set said texel components to a target texel component value.

22. (Allowed) A system for morphing and displaying a texture comprising:

a color decomposer that pre-decomposes at least some texels of a texture map into respective texel color components;

a predeterminer that predetermines incremental texture component morph parameters based on said decomposed texels and target morph texture texel color component states,

an incremental interpolator that incrementally interpolates, in response to said predetermined incremental morph parameters, said texel components toward said target texel color component states through at least one intermediate morph texel component state; and

a real-time image generator that generates a display based at least in part on said intermediate morph texel component state,

wherein said incremental interpolator repetitively adds said incremental morph parameters to the texel components to produce a corresponding sequence of intermediate morph texel component states;

wherein said incremental interpolator selectively interpolates said texel components based on an interlace factor.

23. (Allowed) A system for morphing and displaying a texture comprising:

a color decomposer that pre-decomposes at least some texels of a texture map into respective texel color components;

a predeterminer that predetermines incremental texture component morph parameters based on said decomposed texels and target morph texture texel color component states,

an incremental interpolator that incrementally interpolates, in response to said predetermined incremental morph parameters, said texel components toward said target texel color component states through at least one intermediate morph texel component state; and

a real-time image generator that generates a display based at least in part on said intermediate morph texel component state,

wherein said incremental interpolator repetitively adds said incremental morph parameters to the texel components to produce a corresponding sequence of intermediate morph texel component states;

further including a conditioner that conditions said incremental interpolation based on an interlace factor.

24. (Rejected) A system as in claim 14 further including a frame counter corresponding to said texel component, and wherein said incremental interpolator selectively increments or decrements said texel component in response to said frame counter.

25. (Rejected) A system as in claim 14 further including a separate array storing said texel component arrays.

26. (Rejected) A system as in claim 25 wherein said texel components comprise red, green or blue color values and an alpha value.

27. (Rejected) An efficient method for morphing and displaying texture-mapped objects using a real-time interactive 3D graphics system including user-manipulable controls, said system displaying at least one 3D texture-mapped object based at least in part on a morphed texture map comprising plural texels defining a texture image, said texture morphing method including:

(a) before real time imaging, pre-decomposing said texture map representing said 2D image into plural texel components and precalculating incremental morph parameter values for the texel components;

(b) during real-time imaging, incrementally changing the values of said plural texel components over time based on said calculated incremental morph parameter values to provide morphed texture maps representing morphed 2D images; and

(c) during real-time imaging, generating images in real time based at least in part on said incrementally-changing texel component values by texture mapping said morphed texture maps to apply said morphed 2D images onto at least one 3D object surface in real time response to user operation of said controls,

wherein said incrementally changing step repetitively adds said calculated incremental morph parameter values to the texel components to produce a corresponding sequence of intermediate morph texel component states defining morphed texture maps representing 2D images.

28. (Allowed) An efficient texture morphing method for morphing and displaying textures using a real-time interactive 3D graphics system including user-manipulable controls, said system displaying at least one 3D texture-mapped object based at least in part on a morphed texture map comprising plural texels, said texture morphing method including:

(a) before real time imaging, pre-decomposing said texture map into plural texel components and precalculating incremental morph parameter values for the texel components;

(b) during real-time imaging, incrementally changing the values of said plural texel components over time based on said calculated incremental morph parameter values; and

(c) during real-time imaging, generating images in real time based at least in part on said incrementally-changing texel component values,

wherein said incrementally changing step repetitively adds said calculated incremental morph parameter values to the texel components to produce a corresponding sequence of intermediate morph texel component states;

wherein said calculating step (a) comprises calculating the value of $\Delta r = (TC-SC) / (FR * T)$, where SC is the source texel component value, TC is the target texel component value, FR is the frame rate and T is the morphing duration.

29. (Allowed) An efficient texture morphing method for morphing and displaying textures using a real-time interactive 3D graphics system including user-manipulable controls, said system displaying at least one 3D texture-mapped object based at least in part on a morphed texture map comprising plural texels, said texture morphing method including:

(a) before real time imaging, pre-decomposing said texture map into plural texel components and precalculating incremental morph parameter values for the texel components;

(b) during real-time imaging, incrementally changing the values of said plural texel components over time based on said calculated incremental morph parameter values; and

(c) during real-time imaging, generating images in real time based at least in part on said incrementally-changing texel component values,

wherein said incrementally changing step repetitively adds said calculated incremental morph parameter values to the texel components to produce a corresponding sequence of intermediate morph texel component states;

wherein said incrementally changing comprises repetitively incrementing or decrementing said plural texel component values by uniform amounts at a first predetermined frequency based on the integer portion of Δr, and adding or subtracting a further integer value at a further predetermined frequency less than said first predetermined frequency.

30. (Allowed) An efficient texture morphing method for morphing and displaying textures using a real-time interactive 3D graphics system including user-manipulable controls, said system displaying at least one 3D texture-mapped object based at least in part on a morphed texture map comprising plural texels, said texture morphing method including:

(a) before real time imaging, pre-decomposing said texture map into plural texel components and precalculating incremental morph parameter values for the texel components;

(b) during real-time imaging, incrementally changing the values of said plural texel components over time based on said calculated incremental morph parameter values; and

(c) during real-time imaging, generating images in real time based at least in part on said incrementally-changing texel component values,

wherein said incrementally changing step repetitively adds said calculated incremental morph parameter values to the texel components to produce a corresponding sequence of intermediate morph texel component states;

wherein said incrementally changing comprises repetitively incrementing or decrementing said plural texel component values by uniform amounts at a first predetermined frequency based on the integer portion of Δr, and adding or subtracting a further integer value at a further predetermined frequency less than said first predetermined frequency; and

wherein said first and second predetermined frequencies are each based on image frame rate.

31. (Allowed) An efficient texture morphing method for morphing and displaying textures using a real-time interactive 3D graphics system including user-manipulable

controls, said system displaying at least one 3D texture-mapped object based at least in part on a morphed texture map comprising plural texels, said texture morphing method including:

(a) before real time imaging, pre-decomposing said texture map into plural texel components and precalculating incremental morph parameter values for the texel components;

(b) during real-time imaging, incrementally changing the values of said plural texel components over time based on said calculated incremental morph parameter values; and

(c) during real-time imaging, generating images in real time based at least in part on said incrementally-changing texel component values,

wherein said incrementally changing step repetitively adds said calculated incremental morph parameter values to the texel components to produce a corresponding sequence of intermediate morph texel component states;

wherein said incrementally changing comprises repetitively incrementing or decrementing said plural texel component values by uniform amounts at a first predetermined frequency based on the integer portion of Δr, and adding or subtracting a further integer value at a further predetermined frequency less than said first predetermined frequency; and

wherein said second predetermined frequency is based on a frame counter that counts a predetermined number of image frames.

32. (Rejected) An efficient texture morphing method for morphing and displaying texture-mapped objects using a real time interactive 3D graphics system including user-manipulable controls, said system displaying at least one 3D object based at least in part on a morphed texture map comprising plural texels representing a 2D image, each texel comprising plural texel components, said texture morphing and display method including:

(a) before real-time imaging, pre-decomposing said texels of said texture map representing a 2D image into plural texel components and precalculating incremental morph parameter values for said texel components, including rounding down calculated incremental interpolation values to the closest integer values to provide integer results and calculating period counter values based on non-integer remainders of said calculated incremental interpolation values;

(b) at least in partial response to user interaction with said controls, changing texel component values at a first periodic frequency based on said integer results;

(c) at least in partial response to said period counter, further changing said texel component values at a second periodic frequency less than said first periodic frequency to compensate for approximation errors introduced by step (b); and

generating an image display based at least in part on said changed and further changed texel component values by texture mapping said morphed texture maps to apply corresponding 2D images onto at least one object surface.

33. (Rejected) In a real-time interactive graphics system including at least one user-manipulable control, a method for generating animation objects in real time by morphing a source texture map representing a 2D source image including plural texels each having plural components, into a target texture map representing a 2D target image including plural texels each having plural components, said method comprising:

(a) calculating incremental morph parameter values for texels of said first texture map, and incrementally interpolating the value of said plural texel components of said first texture map over time based on said calculated uniform incremental morph parameter values so as to morph said first texture map toward said second texture map including repetitively adding said incremental morph parameters to the texel components to produce a corresponding sequence of intermediate morphed texel component states;

(b) using an intermediate texture map generated by step (a) to texture map said intermediate morphed texel component states onto a surface of at least one animation object to thereby apply a morphed 2D image onto said surface;

(c) controlling at least one of the displayed orientation and position of said texture-mapped animation object at least in part in response to user manipulation of said control; and

(d) generating an image based at least in part on said controlled texture-mapped animation object.

34. (Rejected) A storage device for use with a real-time interactive graphics system including at least one user-manipulable control, said storage device storing

information used by said system for generating animation objects in real time by morphing a source texture map representing a 2D source image including plural texels each having plural components, into a target texture map representing a 2D target image including plural texels each having plural components, said storage device comprising:

a first storage portion that stores information controlling said system to calculate incremental morph parameter values for texels of said source texture map, and to incrementally interpolate the values of said plural texel components of said first texture map over time into values of plural texel components of said target texture map by uniform integer amounts based on said calculated incremental morph parameter values so as to morph said source texture map through at least one intermediate texture map toward said target texture map;

a second storage portion that stores information controlling said system to texture-map said intermediate texture map onto at least one surface of an animation object to thereby apply a morphed 2D image onto said surface; and

a third storage portion that stores information controlling at least one of the displayed orientation and position for display of said texture-mapped animation object at least in part in response to user manipulation of said control.